THE JOHNS HOPKINS UNIVERSITY

DEPARTMENT

OF

PHYSICS

FINAL REPORT

NASA/MSC Contract NAS 9-11288

INTERFACE DEFINITION FOR THE FAR ULTRAVIOLET SPECTROMETER EXPERIMENT S169

A Joint Effort of the Principal Investigator and Applied Physics Laboratory

Submitted by

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Submitted by

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ABSTRACT

Contract NAS9-11288, Interface Definition for the Far Ultraviolet Spectrometer Experiment S169, between MSC and The Johns Hopkins University, continued the work on interface definition begun under Contract NAS9-10292. It permitted preparation for a final contract for development, fabrication, test and flight of the Ultraviolet Spectrometer Experiment on an Apollo space mission. Contract NAS9-11288 originally covered the period from 17 August to 16 November 1970, but was amended to extend to 8 January 1971. During this period, two Interface Control Documents were completed and signed off. Three more were essentially completed. Supporting preliminary concept formulation, design study and component investigation, specification and subcontract negotiation were accomplished. Other tasks preparatory to the final contract were also accomplished.

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LIST OF ILLUSTRATIONS

ABBREVIATIONS

ACS	Attitude Control System
APL	Applied Physics Laboratory
BTE	Bench Test Equipment
CSM	Command and Service Module
GSE	Ground Support Equipment
ICD	Interface Control Document
JHU	Johns Hopkins University
KSC	Kennedy Space Center
MSC	Manned Spacecraft Center; Houston, Texas
NR	North American Rockwell
PPS	Pulse per Second
SDS	Spacecraft Data System
SIM	Scientific Instrument Module
UVS	Ultraviolet Spectrometer

SUMMARY

During the period of the contract, the following work has been accomplished:

Interface Control Documents for the Spectrometer Envelope and the Electrical Requirements were completed and signed off.

The Environmental, Functional Requirements and UVS/BTE/Apollo GSE Interface Requirements Interface Control Documents were substantially completed.

Two Interface Working Group meetings were conducted at North American Rockwell Corporation during the contract period. Preparation for these meetings represented the major effort by The Johns Hopkins University under the contract.

Mechanical, electrical and design details were further defined. Preliminary evaluations of critical components were accomplished, discussions with manufacturers of these items were held and specifications were prepared.

A considerable effort was expended in negotiating a contract to provide the instrumentation and services required to conduct the UVS experiment.

1.0 INTRODUCTION

1.1 CONTRACT IDENTIFICATION

This final report covers the work accomplished on Contract NAS9-11288, Interface Definition for the Far Ultraviolet Spectrometer Experiment S169 between the Manned Spacecraft Center (MSC) and The Johns Hopkins University (JHU). The effort on this contract, extended twice by amendments, covered the period from 17 August 1970 to 8 January 1971.

1.2 PURPOSE OF CONTRACT

The work reported herein was initiated to further define the design details of the Ultraviolet Spectrometer (UVS) and to finalize interfaces between the Apollo spacecraft and the UVS during the period of negotiation of an instrumentation and principal investigator contract between JHU and MSC.

1.3 CONTRACT TASKS

The specific Interface Control Documents (ICD's) to which the work under Contract NAS9-11288 was directed had been partially completed under a previous contract (NAS9-10292) between the MSC and JHU. They had been assigned the following document numbers:

MH01-12464-434 - Environmental
MH01-12460-134 - CSM/UVS Spectrometer Envelope

MH01-12461-134 - CSM/UVS Installation

MH01-12462-234 - CSM/UVS Electrical Requirements

MH01-12463-434 - CSM/UVS Functional Requirements

MH01-12465-434 - CSM/UVS Ground Requirements

MH01-12909-234 - UVS/BTE/Apollo GSE Interface Requirements

The specific tasks assigned by the Statement of Work were:

a. Carry out ICD coordination with North American Rockwell (NR) as a first priority. This activity shall include trips to NR and MSC and preparation of drawings of the UVS side of the interface.

b. Update the initial mass properties and thermal requirements interfaces.

c. Initiate detail designs of critical portions of the Spectrometer relating to the ICD's.

d. Prepare specifications for component parts of the Spectrometer which relate to the ICD's.

Amendment 2, which also extended the contract to 8 January 1971, added the following tasks:

e. Prepare preliminary configuration documentation.

f. Perform preliminary design layout of GSE.

g. Perform preliminary design layout of UVS.

h. Prepare interface documentation for subcontracts.

i. Prepare Specifications for the following long lead items:

(1) Mirrors
(2) Gratings
(3) Photomultiplier Tube
(4) Integrated Circuits
(5) Mechanical Structure
(6) Motor and Gear Train

j. Conduct preliminary negotiations with subcontractors for long lead items.

2.0 DISCUSSION

2.1 INTERFACE DEFINITION

The status of the various ICD's at the completion of Contract NAS9-11288 is discussed below. Preliminary work on these ICD's had been carried out under a preliminary study contract (NAS9-10292) during the period from November 1969 to March 1970.

2.1.1 Spectrometer Envelope ICD

The mechanical ICD (MH01-12460-134) has been finalized and signed off. The location and orientation of the UVS in the SIM Bay appears to be ideal from the scientific standpoint; i.e., the look angle is very close to the optimum for observation during normal spacecraft operation in lunar orbit, and interference from light scattering by antennas, handles, ACS jets, etc. is at a minimum. The proposed method of installation in the SIM Bay provides easy means to remove and replace the instrument for a final calibration check.

The ICD drawing delineates the maximum envelope orientation in the SIM, mounting points between the UVS and the SIM, estimated weight, center of gravity location, the access means to the UVS when installed in the SIM, and the electrical connectors for connection to Apollo circuitry and the Bench Test Equipment (BTE).

2.1.2 Electrical Requirements ICD

The Electrical Requirements ICD (MH01-12462-234) was reviewed, updated and signed off. The work which had been accomplished under the first study contract was partially negated because of the shift to the 64 kilobit system and because the data readout format was changed from parallel to serial. The new spacecraft data system was not compatible with the original plan to transmit one eight-bit word each tenth second. The present system permits one 16-bit word every tenth second. This additional data capability has been employed to increase the rate at which spectra are obtained (12 seconds instead of 20 seconds per spectrum). It also permits the use of a linear photon counting system in place of the logarithmic system described in the preliminary study report.

The system design originally conceived involved the use of a 100-pps signal from the Spacecraft Data System (SDS) to generate a 100-cycle square wave voltage which activates the synchronous motor of the grating scan mechanism. However, analysis showed that the 1% frequency variation specified for the signal could possibly cause a reduction in power delivered by the square wave generator because of a dc offset which might be generated. Accordingly, a 400-pps signal from the SDS was substituted to minimize the dc offset problem. The signed off ICD includes the 400-pps signal from the SDS.

Another problem in developing a mutually agreeable ICD was the phase relationship between the 400-pps signal and the 10-pps signal from the SDS. The 10-pps signal (UVS enable gate) is employed to transfer the photoelectron count from the accumulator to the readout register. The electronic design which has evolved required a fixed phase relationship between the two SDS signals in order that the wavelength vs time relationship during each scan can be determined. Here again, although the two signals are generated from the same source and must be locked together, the 1% frequency variation is separately specified for each signal. This problem was finally resolved by formatting the UVS readout sequence with respect to the 400-pps signal. The signed off ICD reflects this resolution and provides a basis for finalizing the UVS electronic system. However, considerable effort was involved in resolving these problems, with the result that the detailed design of the UVS electronic system was not completed.

2.1.3 Environmental ICD

The Environmental ICD (MH01-12464-434) is substantially complete. During the contract a table of α and ϵ values for the instrument thermal control coatings was prepared and guidelines were established for the thermal analytical model to be prepared by JHU/APL for MSC and NR. JHU will request flux information in the SIM Bay for certain nuclear radiations to evaluate the background signal to which the UVS will be subjected. In addition, possible thermal and gaseous contaminations from the RCS jets must be evaluated.

2.1.4 UVS/BTE/Apollo GSE Interface Requirements

The UVS/BTE/Apollo GSE ICD (MH01-12909-234) is substantially complete. Only minor details remain to be filled in. Work performed during the contract resulted in:

a. A request for access to the UVS check-out connector after the UVS installation in the CSM.

b. Recommendation that maintenance be performed by JHU/APL personnel.

c. Establishment of the BTE electrical interfaces.

d. Establishment of preliminary BTE configuration and weights.

e. Definition of the necessary mechanical GSE.

f. Establishment of the ground environment requirements for the SIM Bay and the bench maintenance area.

g. Establishment of ground handling requirements.

h. Development of the sequence of ground checkout operations at KSC.

i. Establishment of block diagrams for the functional baseline test, combined system test and integrated test.

2.1.5 Functional Requirements ICD

The Functional ICD (MH01-12463-434) is acceptable to JHU subject to MSC and KSC approval of several procedural details. In addition, the time line must be finalized before this ICD can be signed off because the experimental plan is dependent upon it and, therefore, changes to the time line could require modifications to the ICD.

2.2 DESIGN STUDIES

2.2.1 Electronic and Electrical Considerations

The conceptual design of the electrical and electronic system is complete. The photomultiplier tube and its characteristics have been defined and the pulse detecting and pulse counting circuits have been chosen. The electrical system for the motor drive unit, the solar sensor actuated shutter and the housekeeping functions have been defined. Weight and power requirements for the electronic system have been tentatively determined to be less than 10 lbs. and 10 watts respectively. A block diagram of the UV Spectrometer has been prepared and is shown in Figure 1.

In support of the above, preliminary discussions and evaluations of certain critical components were accomplished. Specific discussions with manufacturers of synchronous motors and drive systems were held. Such discussions involved detailed technical specifications as well as review of quality control and reliability problems and cost and delivery estimates. Also, similar discussions were held with EMR Photoelectric concerning the photomultiplier tube and high voltage power supply. These discussions were the necessary foundations for the final specifications of the motor assembly and the photomultiplier tube assembly.

A preliminary concept of the BTE was generated and from it a preliminary block diagram of the BTE was made. This is shown in Figure 2.

2.2.2 Optical-Mechanical Considerations

The basic work describing the optical-mechanical system, accomplished during the previous study (NAS9-10292), was described in "Preliminary Design Study of a Far Ultraviolet Spectrometer for an Apollo Orbiting Mission, Final Report" January 28, 1970. Further studies during the period of this contract have more precisely defined the structural and mechanical details which are covered in the following paragraphs.

A trade-off study to determine the material and fabrication techniques for the main housing included consideration of a welded plate structure, aluminum casting, honeycomb structure and a structure machined from a single aluminum block. Weight, stability, strength, time limitations, thermal characteristics, and manufacturing problems were weighed. The honeycomb structure had the least weight but lacked thermal balance. The single aluminum block design was superior to all others on most points but time limitations preclude its use. The welded structure involved manufacturing problems and potential mechanical instability due to strains induced by the welding. The aluminum casting, although several pounds heavier than the honeycomb structure, was chosen for its greater stability, strength, ease of manufacture and thermal conductivity properties.

The dimensions and design of the grating blank and the Ebert Mirror blank were finalized and preliminary specifications for these items were prepared.

A study was made of the internal configuration of the external entrance slit baffle. This study showed that a third section could be added at the front end to provide more complete rejection of direct solar radiation and of solar radiation scattered from the lunar surface.

The grating drive motor system was studied and several trade-offs were considered. The hermetically sealed motor-gear box system used for the Mariners VI and VII UVS was rejected on the grounds that such design complexity was not necessary for a mission of Apollo's short duration. An open motor vented to the outside of the spectrometer housing to exclude possible contaminents from the optics space has been chosen. Preliminary design specifications were in preparation at the end of the contract.

The dimensional design of the exit slit mirrors was completed and a conceptual structural design was evolved. The design requires that the entrance slit have three straight sections, approximately equal in length and with the top and bottom sections tilted in toward the Ebert Mirror by an angle of about 30°. This shape of the entrance slit provides an in-focus image of the ends of the entrance slit on the exit slit and improves the spectral resolution of the system. More important, it provides a larger signal frc . the line emissions from the lunar atmosphere when the spectrometer scans the wavelength on which that emission is centered.

The use of straight slits in an Ebert Spectrometer provides a curved spectral line which degrades the spectral resolution. An analytical study of this problem has shown that the exit slit mirrors can be tilted slightly about an axis perpendicular to the slit and parallel to the central ray to reduce this optical distortion to a negligible factor. The slit-mirror structure will be designed to include this adjustment.

A more detailed conceptual design of the optical-mechanical system has been developed. It is shown in the exploded isometric view in Figure 3. In this concept, the main housing provides the mechanical interface to the spacecraft. The Ebert Mirror is a separate subassembly that attaches to the main housing.

The slit plate, which also attaches to the main housing, is the mounting base for all of the remaining components; namely, the voltage converters, detector, solar sensors, detector and sensor electronics, counting circuits, electrical interface connectors, entrance slit baffle, motor drive cam system, grating holder and bearings, wavelength fiducial system, internal baffles and exit slit mirror assembly. From the standpoint of optical-mechanical stability, ease of optical adjustment, weight reduction and ease of electronic assembly, this design appears to be superior to earlier flight instruments. A preprototype of this design has been independently financed and authorized by NASA headquarters and will be flown on an ionospheric rocket experiment in June 1971. Performance data from this flight will be available before the critical design review for the Apollo 17 UVS.

2.3 ADDITIONAL EFFORT

The work on Contract NAS9-11288 reported herein was accomplished during a period when negotiations were underway for a final contract to perform the UVS Experiment. The final contract started at the conclusion of Contract NAS9-11288. Consequently, much effort during the contract period, not reported herein, was required in preparing for the main contract; particularly the internal effort at APL in organizing personnel, preliminary specification writing, and conferences with potential subcontractors which were helpful in determining some of the tradeoff decisions reported herein.

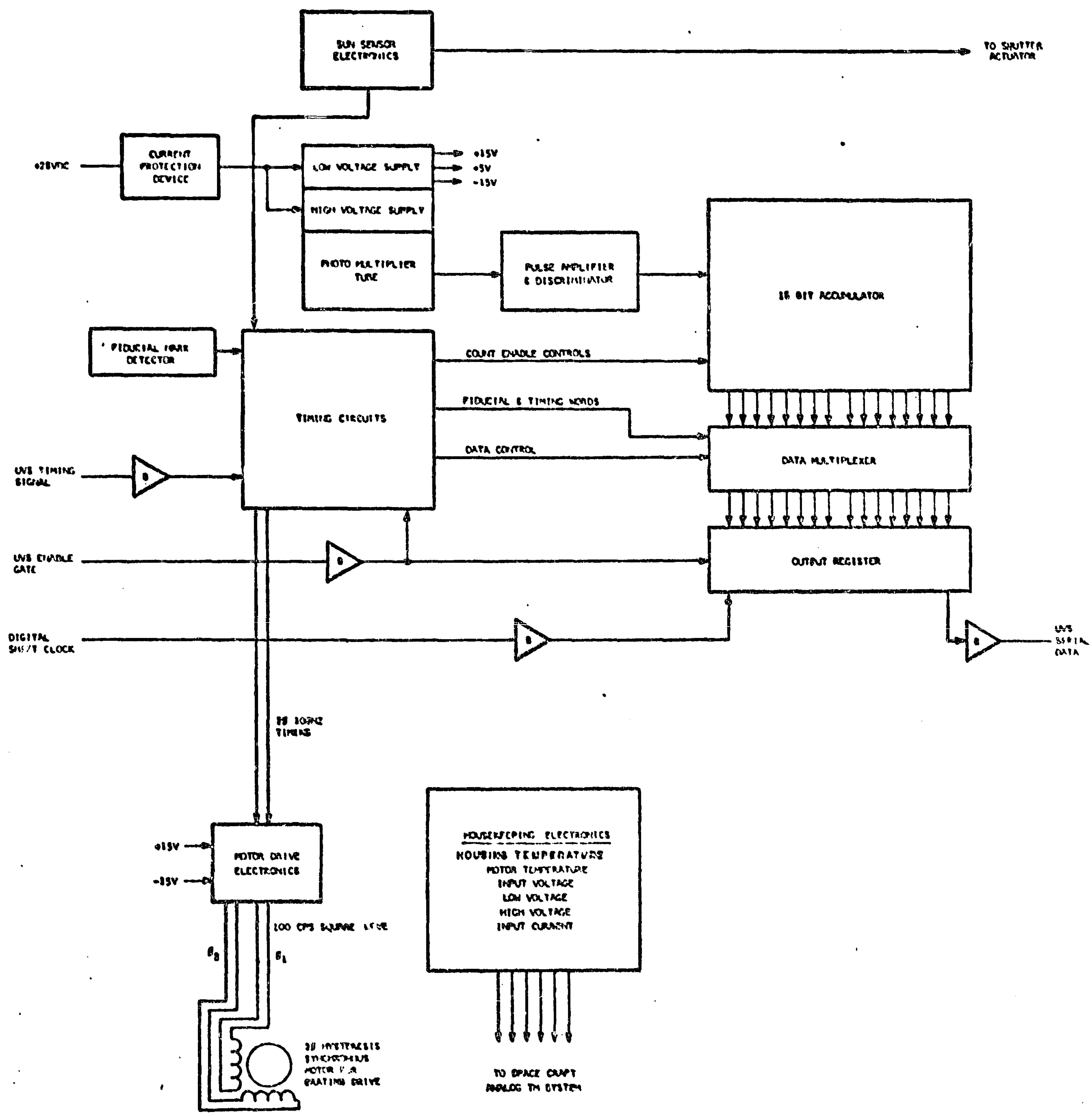
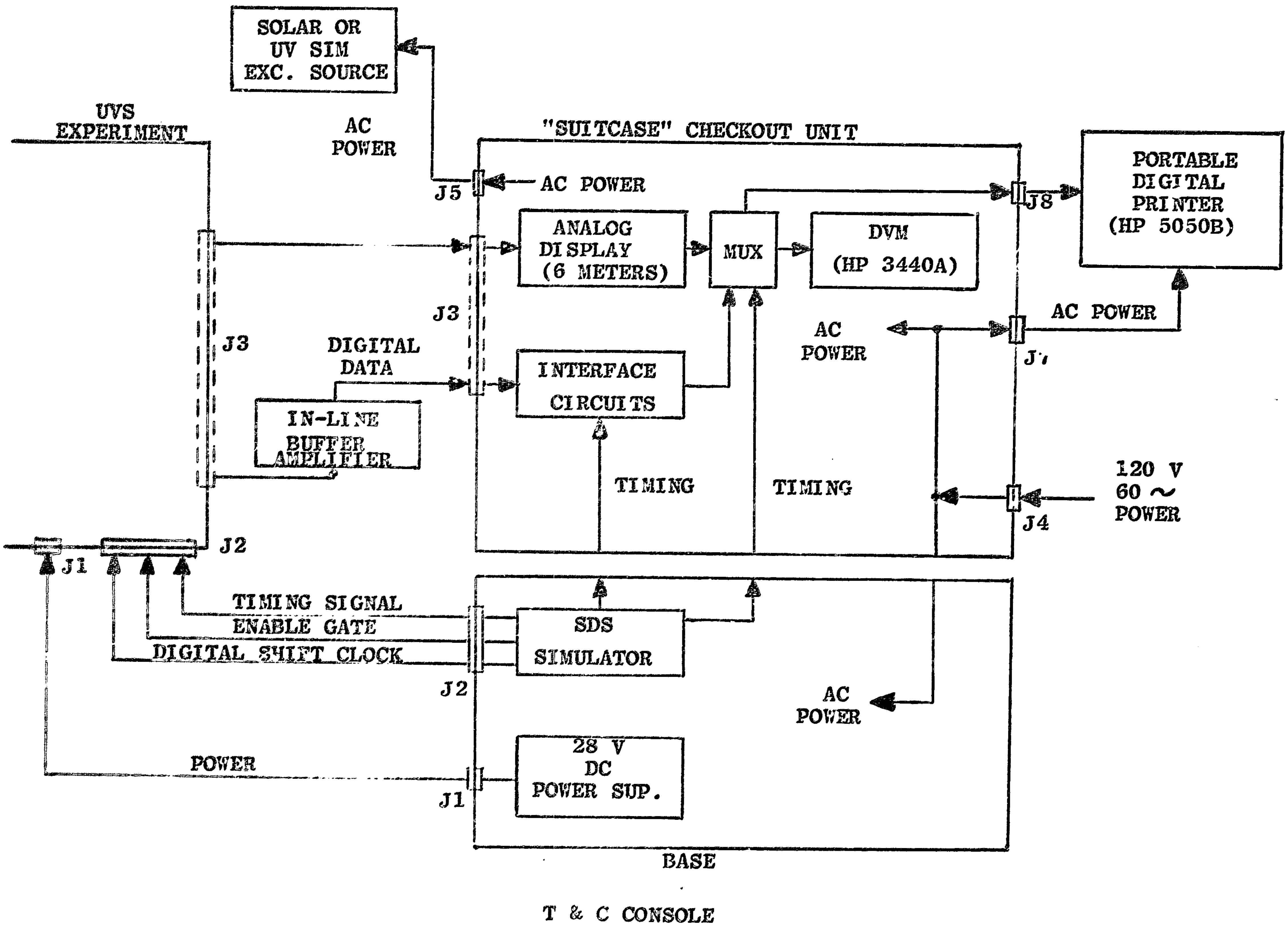


FIGURE 1 - BLOCK DIAGRAM FOR UV SPECTROMETER

FIGURE 2 - UV SPECTROMETER BTE BLOCK DIAGRAM



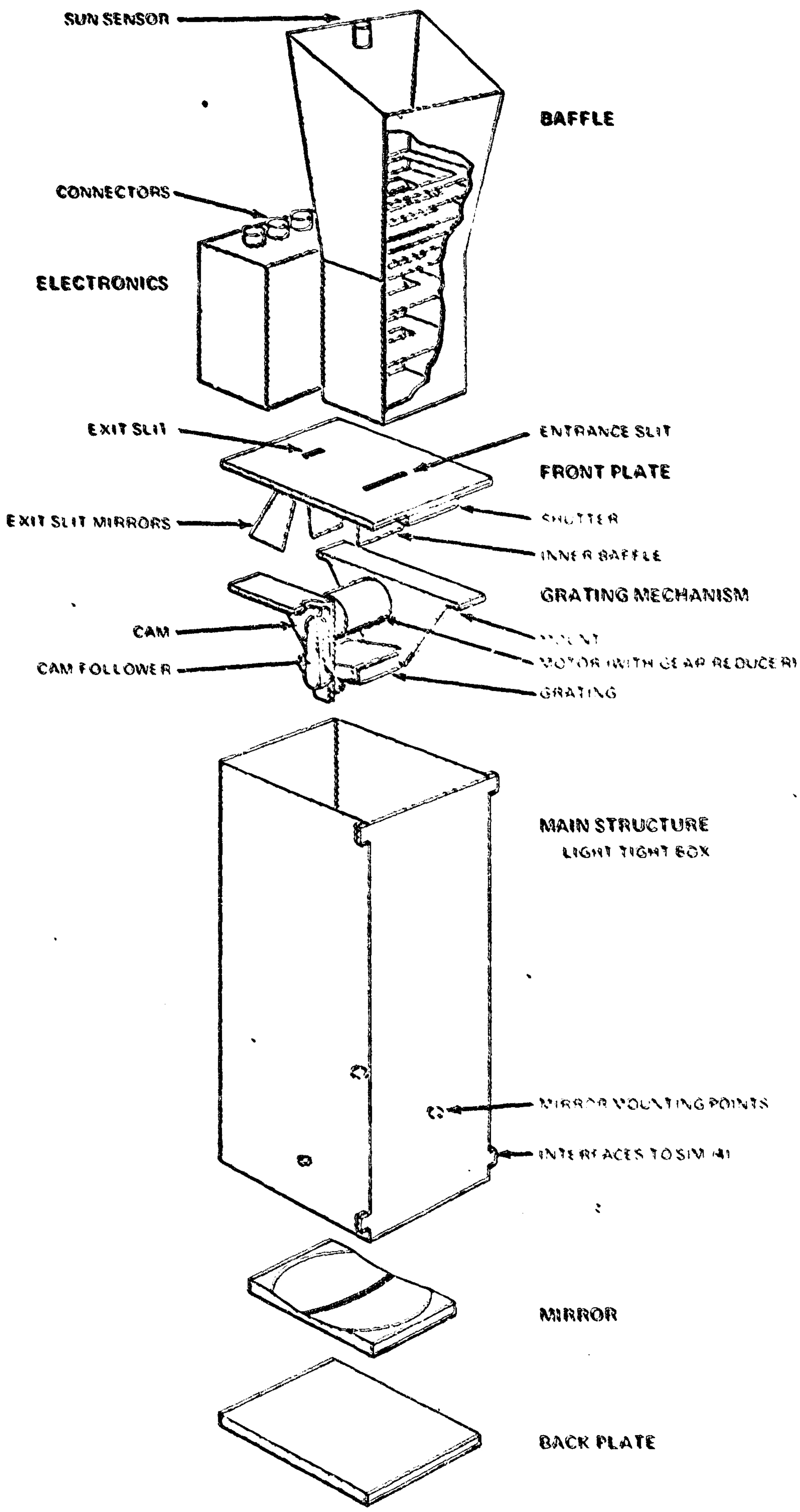


FIGURE 3 - UVS EXPLODED VIEW